

Removable Equipment Housing for Downhole Measurements

DESCRIPTION

[Para 1] STATEMENT OF RELATED CASES

[Para 2] The subject matter of the present application is, in a general sense, related to the subject matter disclosed in pending U.S. Patent Application Serial No. 10/709,625, filed on May 18, 2004, entitled "Equipment Housing for Downhole Measurements," which is hereby incorporated by reference in its entirety.

[Para 3] BACKGROUND OF THE INVENTION

[Para 4] 1. FIELD OF THE INVENTION

[Para 5] The present invention is generally related to the field of data acquisition related to oil and gas wells, and, more particularly, to a removable sealed housing for equipment that may be employed in obtaining downhole measurement data.

[Para 6] 2. DESCRIPTION OF THE RELATED ART

[Para 7] Oil and gas wells are formed by a rotary drilling process. To that end, a drill bit is mounted on the end of a drill string which may be very long, e.g., several thousand feet. At the surface, a rotary drive mechanism turns the drill string and the attached drill bit at the bottom of the hole. In some cases, a downhole motor may provide the desired rotation to the drill bit. During

drilling operations, a drilling fluid (so-called drilling mud) is pumped through the drill string and back up-hole by pumps located on the surface. The purpose of the drilling fluid is to, among other things, remove the earthen cuttings resulting from the drilling process.

[Para 8] The environmental conditions that exist downhole in oil and gas wells can be very important to drilling, production and completion operations. For example, downhole temperatures and pressures as well as fluid viscosities can greatly impact various operations that are involved in creating a productive oil and gas well. More specifically, with respect to drilling operations, there is a growing desire to obtain as much data as possible regarding downhole environmental and operating conditions. Such data may be useful for research purposes, as well as, in some cases, taking actions with respect to drilling a particular well or future wells. Additionally, it may be desirable to provide positional information, e.g., depth, and relative location of a drilling bit, such that a well may be properly drilled to a desired target zone.

[Para 9] While there are existing methodologies for acquiring some forms of downhole data, such methodologies tend to be relatively expensive and difficult to employ. What is desired is a relatively low-cost mechanism and procedure for acquiring downhole measurement data. The provision of such a mechanism would allow its use on a far greater number of wells, thereby providing much more information that may be useful in drilling and completing future oil and gas wells.

[Para 10] The present invention is directed to an apparatus and methods for solving, or at least reducing the effects of, some or all of the aforementioned problems.

[Para 11] SUMMARY OF THE INVENTION

[Para 12] The present invention is generally directed to a removable sealed housing for equipment that may be employed in obtaining downhole measurement data. In one illustrative embodiment, the apparatus comprises a component adapted to be positioned in a subterranean wellbore, the component having a recess formed therein, a detachable sealed housing removably coupled to the component, at least a portion of the detachable sealed housing being positioned in the recess, the housing having at least one cavity formed therein, and at least one device positioned in the cavity. In some cases, substantially all of the detachable sealed housing may be positioned within the recess in the component.

[Para 13] In another illustrative embodiment, the apparatus comprises a component adapted to be positioned in a subterranean wellbore, the component having a recess formed therein, a detachable sealed housing threadingly coupled to the component, at least a portion of the detachable sealed housing being positioned in the recess, the detachable sealed housing having at least one cavity formed therein, and at least one of a sensor and an electrical component positioned in the cavity.

[Para 14] In yet another illustrative embodiment, the apparatus comprises a component adapted to be positioned in a subterranean wellbore, the component having a surface, a detachable sealed housing removably coupled to the surface of the component, the detachable sealed housing having at least one cavity formed therein, and at least one device positioned in the cavity. The detachable sealed housing may be removably coupled to the surface by use of one or more threaded fasteners.

[Para 15] In one illustrative embodiment, the method comprises positioning a detachable sealed housing at least partially in a recess formed in a component adapted to be positioned in a subterranean wellbore, removably coupling the

detachable sealed housing to the component wherein at least a portion of the detachable housing is positioned in the recess formed in the component, the detachable sealed housing having at least one cavity formed therein and at least one device positioned within the cavity, positioning the component and the detachable sealed housing in the subterranean wellbore, and acquiring data using the at least one device after the detachable sealed housing is positioned within the subterranean wellbore.

[Para 16] In another illustrative embodiment, the method comprises positioning a detachable sealed housing adjacent a surface of a component adapted to be positioned in a subterranean wellbore, removably coupling a detachable sealed housing to the surface of the component, the detachable sealed housing having at least one cavity formed therein and at least one device positioned within the cavity, positioning the component and the detachable sealed housing in the subterranean wellbore, and acquiring data using the at least one device after the detachable sealed housing is positioned within the subterranean wellbore.

[Para 17] BRIEF DESCRIPTION OF THE DRAWINGS

[Para 18] The invention may be understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements, and in which:

[Para 19] Figure 1 is an illustrative example of a downhole component comprising a plurality of removable sealed housings in accordance with one embodiment of the present invention.

[Para 20] Figures 2A–2C depict illustrative embodiments of a detachable sealed housing in accordance with the present invention.

[Para 21] Figures 3A–3B depict yet another illustrative embodiment of a detachable sealed housing in accordance with the present invention.

[Para 22] Figures 4A–4B depict an embodiment of the present invention wherein the detachable sealed housing is configured as a ring segment.

[Para 23] Figures 5A–5D depict various techniques that may be employed to attach a detachable sealed housing of the present invention to a downhole component.

[Para 24] Figures 6A–6C depict yet another illustrative technique for coupling a detachable sealed housing of the present invention to the downhole component.

[Para 25] Figure 7 depicts yet another illustrative embodiment of a manner in which a detachable sealed housing of the present invention may be attached to a downhole component.

[Para 26] Figures 8A–8B depict illustrative examples wherein a detachable sealed housing of the present invention may be part of a nozzle employed with downhole drill bits.

[Para 27] Figure 9 depicts an illustrative example wherein a detachable sealed housing of the present invention may be formed as part of a component positioned in a downhole component for various reasons.

[Para 28] Figures 10A–10C depict one illustrative embodiment of the present invention wherein the detachable sealed housing may be configured to receive or send data obtained from a sensor positioned in a downhole component.

[Para 29] Figure 11 is a view of a plurality of indicator lights and a display panel that may be employed with various embodiments of the present invention.

[Para 30] Figures 12A–12B depict an illustrative example wherein a plurality of detachable sealed housings of the present invention may be employed on an illustrative drill string.

[Para 31] Figures 13A–13B depict an illustrative example wherein a plurality of detachable sealed housings of the present invention may be employed with wired pipe sections.

[Para 32] While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

[Para 33] DETAILED DESCRIPTION OF THE INVENTION

[Para 34] Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the

development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[Para 35] The present invention will now be described with reference to the attached figures. The words and phrases used herein should be understood and interpreted to have a meaning consistent with the understanding of those words and phrases by those skilled in the relevant art. No special definition of a term or phrase, i.e., a definition that is different from the ordinary and customary meaning as understood by those skilled in the art, is intended to be implied by consistent usage of the term or phrase herein. To the extent that a term or phrase is intended to have a special meaning, i.e., a meaning other than that understood by skilled artisans, such a special definition will be expressly set forth in the specification in a definitional manner that directly and unequivocally provides the special definition for the term or phrase.

[Para 36] In general, the present invention is directed to a removable sealed housing that may be removably coupled to a downhole component that is adapted to be positioned in a subterranean hole, e.g., a wellbore. In one illustrative embodiment, the removable sealed housing may have one or more cavities wherein one or more devices, e.g., sensors and/or electrical components, may be positioned in such cavities. In one very particular embodiment, the detachable sealed housing contains at least one cavity wherein at least one sensor may be positioned for acquiring various forms of downhole data. As will be recognized by those skilled in the art after a complete reading of the present application, the present invention may be employed in connection with acquiring any of a variety of different types of data, and the detachable sealed housing disclosed herein may be coupled to

any of a variety of different types of downhole components, e.g., a tubular component, a bottom hole assembly, a downhole sub, a drill bit, etc. Thus, the present invention should not be considered as limited to the acquisition of any particular type of data, or as to the coupling of the detachable sealed housing disclosed herein to any particular type of downhole component, unless such limitations are expressly set forth in the appended claims. Nor should the present invention be considered as limited to use with only sensors positioned in the cavities of the detachable sealed housing, as a variety of items or devices may be positioned in the cavities formed in the detachable sealed housing.

[Para 37] In general, in one illustrative embodiment, the present invention is directed to a removable sealed housing that may be positioned, at least partially, in a recess or opening formed in a downhole component. Figure 1 depicts the illustrative situation where a removable sealed housing 10 in accordance with the present invention may be positioned in a recess 40 formed in an illustrative drill bit 14. Additionally, as depicted in Figure 1, a removable sealed housing 10 of the present invention may be positioned in a recess 40 formed in a tubular component 12, e.g., pipe, that is adapted to be positioned in a subterranean wellbore. The number of detachable sealed housings 10 employed on a given downhole component or a string of various components, e.g., a drill string, may vary depending upon the particular application.

[Para 38] As will be recognized by those skilled in the art after a complete reading of the present application, the present invention has broad applicability and may be employed with any of a variety of components that may be positioned in a subterranean wellbore. For example, the present invention may be employed with drill bits, tubular components, bottom hole assemblies, drilling motors, electrical submersible pumps, fishing tools, whipstocks, packers, etc. Thus, the present invention should not be considered as limited to use with any particular type of downhole component.

As will be understood after a complete reading of the present application, the removable sealed housing 10 of the present invention may take a variety of shapes and configurations, and it may be installed using a variety of techniques. Various illustrative examples will be described in the specification, however, the present invention should not be considered as limited to these specifically disclosed embodiments as they are illustrative in nature. Moreover, the removable sealed housing 10 may be coupled to the downhole component using a variety of techniques. Accordingly, the particular techniques disclosed herein for coupling the housing 10 to the downhole component are illustrative in nature only, and should not be considered a limitation of the present invention unless such limitations are expressly set forth in the appended claims.

[Para 39] Figures 2A–2B depict one illustrative embodiment of the detachable sealed housing 10 in accordance with the present invention. Figure 2A is a cross-sectional side view of the detachable sealed housing 10, whereas Figure 2B is an end view of the detachable sealed housing 10. As shown in these drawings, the detachable sealed housing 10 is generally comprised of a body 20 having a bottom surface 19 and at least one cavity 18 formed therein. The detachable sealed housing 10 depicted in Figures 2A–2B further comprises external threads 24 and a socket 22 that will be used to facilitate removal of the detachable sealed housing 10 from the downhole component. One or more devices 29 may be positioned within the cavity 18 formed in the detachable sealed housing 10. The particular embodiment of the detachable sealed housing depicted in Figures 2A–2B has a generally cylindrical configuration, and it is adapted to be threadingly coupled to a downhole component (not shown) via the external threads 24.

[Para 40] In the embodiment depicted in Figures 2A–2C, the detachable sealed housing 10 further comprises a cover plate 20a that is threadingly secured to the body 20 by a plurality of threaded fasteners 22a. A seal 24a is provided between the cover plate 20a and the body 20 of the detachable

sealed housing 10 to define at least one sealed cavity 18 in the housing 10. As used herein, the term sealed housing shall be understood to mean a housing comprised of at least one cavity 118 formed therein wherein the cavity 18 is sealed to prevent the ingress of gases and/or fluids into the cavity 18. Figure 2C depicts an illustrative alternative embodiment depicting how the illustrative cover plate 20a may be sealingly coupled to the body 20 of the detachable housing 10 of the present invention. As shown therein, the cover plate 20a may be threadingly coupled to the body 20 by a threaded connection 26a, e.g., external threads formed on the body 20 and internal threads formed on the cover plate 20a. The seal 24a is disposed between the cover plate 20a and the body 20. As will be recognized by those skilled in the art after a complete reading of the present application, the exact manner in which the sealing described above may be accomplished may vary depending on the particular application. Various illustrative examples are discussed herein for purposes of explanation only, but they should not be considered a limitation of the present invention.

[Para 41] As indicated previously, the present invention may be employed in a variety of different applications. In one illustrative example, the detachable sealed housing 10 may have at least one device 29, e.g., at least one sensor and/or at least one item of electrical equipment, positioned in the cavity 18. Thus, as depicted in Figures 2A–2B, a plurality of devices 29 are shown positioned within the cavity 18. More specifically, in the depicted embodiment, the devices 29 comprise a plurality of sensors 30 and a plurality of electrical components 31 that are mounted on a surface 18a of the cavity 18. It should be understood that the depicted sensors 30 and electrical components 31 are schematic and illustrative in nature. Moreover, in some cases, some of the devices employed in obtaining downhole data, e.g., one or more sensors, may be mounted in or on another structure, e.g., a drill bit, and the cavity 18 may contain only various electrical components. In other cases, only sensors are mounted within the cavity 18 and the electrical components are positioned elsewhere, e.g., a downhole sub.

[Para 42] The manner in which such devices, e.g., sensors 30 and/or electrical components 31, are coupled together so as to obtain the desired data are well known to those skilled in the art and thus will not be described in any greater detail herein. The sensors 30 and the electrical components 31 may be mounted to the surface 18a by a variety of known techniques, e.g., gluing, use of a potting compound, etc. Moreover, although only the surface 18a is depicted as having the sensors 30 and the electrical components 31 mounted thereon, such items may be mounted on any or all of the surfaces of the cavity 18 depending upon the particular application. Thus, the present invention should not be considered as limited to any particular type of sensor 30 or electrical component 31 or how such items are mounted within the cavity 18 of the detachable sealed housing 10 of the present invention. After the devices 29 are mounted in the cavity 18, the cavity 18 may be substantially filled with a potting compound or other material.

[Para 43] In general, in one illustrative embodiment, the present invention may be used to facilitate the acquisition of data regarding any of a variety of different types of downhole data or information, including, for example, formation type, well temperature, well pressure, drill bit accelerations, velocities and displacements, drill bit inclination and azimuth, drill bit axial load and rotational torque, drill bit rotary speed and rate of penetration, chemical sensors for grease analysis, pH sensors, oxygen sensors, NO_x sensors, carbon monoxide sensors, etc. The present invention may also be employed to acquire ring compression data that may be indicative of successful make-up. Strain gauges may be employed in such an illustrative application. The present invention may also be employed to acquire data relating to drill pipe accelerations as well as data relating to the dynamic behavior of any bottom hole assembly (BHA).

[Para 44] Examples of sensing devices 30 that may be positioned within the cavity 18 include any of a variety of different types of mechanical and/or

electrical sensors, e.g., thermometers, gyroscopes, strain gauges, accelerometers, barometers, pressure sensors, hall effect switches, etc. Examples of electrical components 31 that may be positioned within the cavity 18 include, but are not limited to, a battery, a microprocessor, a memory unit or chip, a circuit board, a communications port, and/or an analog-to-digital converter, etc. If desired or necessary, a plurality of such components may be positioned within the cavity 18, e.g., multiple batteries. The sensors 30 and electrical components 31 may be coupled together in any of a variety of known techniques.

[Para 45] As indicated previously, the detachable sealed housing 10 may be of any desired shape, and any number of sealed cavities 18 may be formed within the housing 10. Moreover, the shape and configuration of the cavities 18 may also vary depending upon the particular application. Figures 3A–3B depict another illustrative embodiment of the present invention wherein the body 20 of the detachable sealed housing 10 has a generally rectangular configuration and a plurality of cavities 18 are formed in the detachable sealed housing 10. Also, in the illustrative embodiment depicted in Figures 3A–3B, the cavities 18 have a generally rectangular configuration. As in Figures 2A–2C, a cover plate 20a and seal 24a are provide to define the sealed housing 10 with the cavities 18 therein.

[Para 46] Figures 4A–4B depict yet another illustrative embodiment of the detachable sealed housing 10 of the present invention wherein the detachable sealed housing 10 has a configuration of a partial ring segment. As shown therein, the body 20 comprises an inner surface 20i, an outer surface 20o, a top surface 20t and a bottom surface 20b. Two illustrative generally rectangular cavities 18 are formed therein and are open to the interior surface 20i of the detachable sealed housing 10. Alternatively, the cavities 18 can open to any surface of the body 20. A plurality of sensors 30 and electrical components 31 are positioned among the cavities 18 formed in the detachable sealed housing 10.

[Para 47] In one illustrative embodiment, at least a portion of the detachable sealed housing 10 is adapted to be positioned in a recess or opening 40 formed in a body 11 of an illustrative downhole component. In other embodiments, substantially the entirety of the detachable sealed housing 10 may be positioned within the recess 40. The manner in which the detachable sealed housing 10 is coupled to the downhole component 11 may vary depending upon the particular application. Again, it should be understood that the downhole component 11 is depicted by way of example only as it may be any type of device adapted to be positioned in a subterranean wellbore. The following are illustrative examples of how the detachable sealed housing 10 of the present invention may be removably coupled to the downhole component 11.

[Para 48] As shown in Figure 5A, in one illustrative embodiment, the detachable sealed housing 10 is a generally cylindrical component that may be threadingly coupled to the downhole component 11. More specifically, the detachable sealed housing 10 depicted in Figure 5A comprises external threads 38 that are adapted to threadingly engage internal threads 36 within the recess 40 formed in the downhole component 11. A seal 34 may be provided between the detachable sealed housing 10 and the component 11 if desired to provide redundancy with respect to preventing ingress of undesirable fluids into the cavity 18. However, since the detachable sealed housing 10 is itself sealed to prevent the ingress of fluids into the cavity 18, the extra seal 34 may or may not be employed depending on the particular application. A socket recess 22 is formed in the body 20 of the detachable sealed housing 10 to facilitate removal of the detachable sealed housing 10 from the recess 40. A plurality of cavities 18 are formed in the body 20 of the detachable sealed housing 10 depicted in Figure 5A.

[Para 49] Figure 5B depicts an illustrative situation where a split ring 50 is used to secure the detachable sealed housing 10 within the recess 40 formed

in the downhole component 11. More specifically, the split ring 50 is adapted to engage a groove 51 formed in the downhole component 11 to thereby retain the detachable sealed housing 10 in the recess 40. As indicated above, a seal 34 may be provided between the detachable sealed housing 10 and the downhole component 11 if desired, but it is not necessary to practice various aspects of the present invention. As with other embodiments disclosed herein, the detachable sealed housing 10 in Figure 5B comprises a plurality of cavities 18 formed therein. Illustrative sensors 30 and electrical components 31 are positioned in the cavities 18.

[Para 50] Figure 5C depicts yet another illustrative embodiment wherein a cover plate 60 is removably coupled to the downhole component 11 by a plurality of fasteners 52 to thereby secure the detachable sealed housing 10 within the recess 40 defined in the downhole component 11. The number of fasteners 52 employed as well as the specific type of fasteners employed may vary depending upon the particular application. In one illustrative embodiment, the fasteners 52 are threaded bolts that are adapted to threadingly engage the downhole component 11. Similar to the embodiments discussed previously, a seal 34 may be provided between the cover plate 60 and the downhole component 11 as indicated in Figure 5C. In this illustrative embodiment, the detachable sealed housing 10 comprises a single cavity 18.

[Para 51] Figure 5D depicts yet another illustrative embodiment of the detachable sealed housing 10 of the present invention that may be removably coupled to a downhole component 11. As shown therein, the body 20 of the detachable sealed housing 10 has a nose end 25 that is adapted to be positioned in a groove 41 that forms part of the recess 40. The recess 40 has a tapered surface 46 that is adapted to engage a tapered surface 26 formed on the body 20 of the detachable sealed housing 10. A threaded fastener 56 having a tapered surface 57 is adapted to engage a tapered recess 27 formed on the body 20 of the detachable sealed housing 10. In practice, when the threaded fastener 56 is in a retracted position, the detachable sealed housing

10 may be inserted into the recess 40. Thereafter, by advancing a threaded fastener 56, the detachable sealed housing 10 may be secured in the recess 40 due to engagement of the tapered surface 57 with the tapered recess 27 and the engagement of the tapered surface 26 on the detachable sealed housing 10 with the tapered surface 46 of the recess 40. The detachable sealed housing 10 depicted in Figure 5D comprises a plurality of cavities 18 that are open to an interior surface 20i of the body 20.

[Para 52] The present invention may also be employed in situations in which the removable sealed housing 10 is removably coupled to a surface 11a of a downhole component 11. The surface 11a may be an interior surface or an exterior surface of the component 11. In one particular embodiment, the surface 11a may be an external cylindrical surface of the component 11. As shown in Figure 6A, the detachable sealed housing 10 may be removably coupled to the surface 11a by a plurality of threaded fasteners 52 that extend through openings 21 formed in the housing 10 and threadingly engage the downhole component 11. In one embodiment, a plurality of such fasteners 52 may be used to secure the detachable sealed housing 10 to the component 11. For example, as shown in Figure 6B, four illustrative fasteners 52 are used to secure the detachable sealed housing 10 to the component 11. Figure 6C depicts the illustrative example where a single threaded fastener 52 is used to secure the detachable sealed housing 10 to the component 11. An additional seal 24b may be employed in this embodiment between the cover plate 20a and the body 20. As indicated in Figure 6C, the housing 10 has four illustrative cavities 18 having components 30, 31 formed therein. Of course, the configuration of the detachable sealed housing 10 depicted in Figures 6A–6C is illustrative in nature.

[Para 53] Figure 7 depicts yet another illustrative embodiment of the present invention wherein the detachable sealed housing 10 is coupled to the downhole component 11 via a hinged connection 70. More specifically, a retaining plate 72 and a plurality of fasteners 52a, 52b are used to secure the

body 20 of the detachable sealed housing 10 within the recess 40. The threaded fastener 52a extends through the retaining plate 72 and is threadingly coupled to the component 11, whereas the threaded fastener 52b extends through the retaining plate 72 and is threadingly coupled to the body 20 of the housing 10.

[Para 54] The body 20 of the detachable sealed housing 10 may serve other useful purposes in addition to housing the sensors 30 and/or electrical components 31. For example, in the embodiment shown in Figures 8A–8B, the body 20 of the detachable sealed housing 10 is configured as a nozzle 82 that is adapted to be positioned in an opening 81 formed in the body of a drill bit 80. As will be recognized by those skilled in the art after a complete reading of the present application, drilling mud or fluid may be pumped down through the nozzle 82 in the direction indicated by the arrow 85. The detachable sealed housing 10 is secured within the opening 81 in the drill bit 80 by a snap ring 84. In this particular embodiment, the internal surface 55 of the body 20 of the detachable sealed housing 10 is configured to act as a nozzle to thereby increase the velocity of the drilling fluid exiting the nozzle 82. One or more cavities 18 are formed in the body 20 of the detachable sealed housing 10 as with other embodiments of the present invention. Stated another way, the cavities 18 described herein may be formed in a standard nozzle body used in the drilling industry, and one or more devices, e.g., a sensor 30 and/or electrical component 31, may be positioned in the cavity 18. Figure 8B depicts yet another illustrative embodiment wherein the detachable sealed housing 10 is configured as a nozzle 82, and the detachable sealed housing 10 is threadingly coupled to the drill bit body 80 by the threaded connection 86. One or more cavities 18 are formed in the housing 10. As depicted therein, one or more cover plates 20a are used to cover the cavities 18 and the cover plates 20a are secured to the detachable sealed housing 10 by a plurality of threaded fasteners 22b.

[Para 55] Figure 9 depicts the illustrative example wherein the detachable sealed housing 10 of the present invention is part of another component positioned in a downhole component. For example, as indicated in Figure 9, the detachable sealed housing 10 may be part of a grease reservoir 90 that is removably positioned within a drill bit body 80. More specifically, the body 97 of the grease reservoir 90 is adapted to be removably coupled to the drill bit body 80 by a snap ring 94 that mates with corresponding grooves 93 formed in the drill bit body 80 and the body 97. A seal 96 is provided between the body 97 and the drill bit body 80. The body 97 has at least one cavity 18 formed therein that is adapted to receive one or more of the sensors 30 and/or electrical components 31. A threaded cover plate 20a is used to cover the cavity 18 and secured to the body 97 by a threaded connection 92. A seal 24a is provide between the cover plate 20a and the body 97.

[Para 56] The present invention may also be employed in situations when the removable sealed housing 10 of the present invention may be adapted to communicate with or receive data from instrumentation, sensors and/or electrical components that are installed in various downhole components. For example, in some applications, it may be desirable to have a sensor located at a particular location within a downhole component, e.g., thermocouple positioned adjacent the bearings of a roller cutter drill bit to sense the temperature experienced by the bearings. To that end, Figures 10A–10C depict an illustrative example where the present invention may be employed in such situations. As shown in Figure 10A, an illustrative sensor 102 is positioned in an opening 100 formed in an illustrative downhole component 11. A wire 101 extends from the sensor to a contact 104. The contact 104 is positioned such that it may be accessed via the recess 40 formed in the component 11. In this particular embodiment, the removable sealed housing 10 comprises a contact ring 41 (see Figures 10B and 10C) formed adjacent the bottom surface 19 of the body 20 that is adapted to engage the contact 104 such that data may be transmitted between and among the sensor 102 and the various components 30, 31 positioned in the cavity 18. The detachable sealed

housing 10 may comprise one or more channels 39 having a wire 43 extending from the contact ring 41 to the components 30, 31 to accomplish such objectives. In this particular embodiment, a cover plate 20a is secured to the body 20 with a plurality of threaded fasteners 22a. A seal 24a is positioned between the cover plate 20a and the body 20.

[Para 57] In various embodiments of the present invention, a plurality of cavities 18 are formed in the detachable sealed housing 10 and the cavities 18 are connected to one another via one or more internal passageways 37 (see Figure 3A). In this illustrative embodiment, the devices, e.g., electrical components 31 and/or sensors 30, positioned in the various cavities 18 may be coupled to one another via wires positioned in the passageways 37. Of course, all of the cavities 18 may not need to be interconnected together by the passageways 37.

[Para 58] As illustratively depicted in Figure 11, the detachable sealed housing 10 may also be provided with one or more indicator lights and/or display panels for various purposes. By way of example only, Figure 11 schematically depicts an illustrative cylindrical embodiment of the detachable sealed housing 10 with a plurality of indicator lights 47 and a display panel 42 operatively coupled to the detachable sealed housing 10, e.g., positioned in an outer surface thereof. In one illustrative embodiment, such components may be positioned such that they may be viewed by an operator looking at the outside of the detachable sealed housing 10 or they may be positioned within one or more of the cavities 18 formed in the detachable sealed housing 10. In one illustrative embodiment, the indicator lights 47 and the display panel 42 may be viewed from the outside when the detachable sealed housing 10 is installed in a recess 40 formed in the component 11, such as when the detachable sealed housing 10 is retrieved from downhole.

[Para 59] In the case where the present invention is employed to obtain downhole data, the indicator lights 47 and/or display panel 42 may be employed in a variety of different contexts. For example, a control logic may be established such that an indicator light is “on” only when a sensed parameter, e.g., temperature, pressure, torque, etc., exceeds a preselected allowable limit or range, i.e., the indicator light can indicate an out-of-tolerance or problem condition. Alternatively, the control logic may be established such that the indicator light is always “on” and only goes off when an out-of-tolerance condition is sensed. Colored indicator lights may also be employed with the present invention, e.g., red and green lights, wherein the red light indicated an out-of-tolerance condition and the green light indicated a within-tolerance condition. The use of such indicator lights may be very useful. For example, through use of the indicator lights 47, an out-of-tolerance event may be quickly identified as soon as the detachable sealed housing 10 is removed from the borehole. In that case, analysis of the data acquired by the devices in the housing 10, e.g., sensors, may be given a very high priority as an out-of-tolerance condition is indicated. Absent the use of such good/bad indicator lights, the analysis of the acquired data may be delayed. Such delays may be very problematic in many situations if corrective actions are delayed. Such indicator lights may be employed for any or all sensed variables depending upon the particular application. The indicator lights 47 may be LED devices that are commonly found in the industry. The lights 47 may be electrically coupled to the equipment, e.g., electrical components 31 and/or sensors 30 positioned in the cavities 18 in the detachable sealed housing 10. The lights 47 may be actuated by known circuitry positioned within the cavities 18. The control logic used to actuate the lights 47 may be embedded in various circuits formed on the electrical components 31 positioned within the cavities 18, e.g., a microprocessor, a programmable logic device, etc.

[Para 60] As indicated in Figure 11, the detachable sealed housing 10 may also be provided with one or more display panels 42. The display panel 42

may be, for example, an LED display panel. The panel 42 may provide information with respect to one or more variables. For example, in the depicted embodiment, the display panel displays the highest temperature sensed during the downhole operation. Of course, the display panel 42 could also indicate other variables, such as maximum downhole pressure, maximum or average torque values, etc. As with the indicator lights 47, the display panel 42 may be coupled to one or more electrical components 31 and/or sensors 30 positioned in the cavities 18 formed in the detachable sealed housing 10.

[Para 61] Thereafter, in the illustrative embodiment where one or more sensors 30 and/or electrical components 31 are positioned within the cavities 18, the detachable sealed housing 10 is removably coupled to a downhole component and the detachable sealed housing 10 and the downhole component are positioned downhole and data is acquired regarding, for example, various downhole environmental conditions or positional information. In one illustrative embodiment, this data is stored in a memory unit or chip positioned within the cavity 18. After sufficient data has been acquired, the detachable sealed housing 10 is brought uphole and the information regarding the acquired data is downloaded and used for any of a variety of research, development or production reasons. In some embodiments, the downloading of the acquired information may be accomplished by an electrical connection or by wireless interrogation using a radio or infrared device. If desired, the cavity 18 may be unsealed by, for example, removing the illustrative cover plate 20a depicted in various embodiments disclosed herein.

[Para 62] In some cases, the detachable sealed housing 10 of the present invention may be employed wherein the data obtained by the sensor(s) positioned within the cavity 18 is sent to the surface on a real-time, or near real-time, basis. To that end, a communication link between the surface and the sensors 30 and/or electrical components 31 within the cavity 18 is

provided and data is transmitted to the surface on a real-time or near real-time basis.

[Para 63] Figures 12A–12C depict another illustrative embodiment of the present invention. As indicated in Figure 12A, a plurality of removable sealed housings 10 of the present invention may be positioned at various spaced-apart locations along a drill string 50 having an illustrative drill bit 14 positioned at the end thereof. In this illustrative embodiment, the drill string 50 is comprised of many sections of standard un-wired pipe. In this illustrative embodiment, data may be sensed by various sensors (not shown in Figure 12A) positioned in or proximate the drill bit 14 and/or in one or more cavities 18 formed in the detachable sealed housing 10. The detachable sealed housing 10 coupled to the drill bit 14 may also contain a schematically depicted wireless transmitter 52 for transmitting data regarding the information or parameters sensed downhole. Each of the other detachable sealed housings 10 contain a transmitter 52 and a schematically depicted receiver 54 that is adapted to receive wireless transmissions from the transmitter 52 in an adjacent housing 10. In some cases, the detachable sealed housing 10 proximate the drill bit 14 may also have a wireless receiver 54. Thus, in this embodiment, the spaced-apart detachable sealed housings 10 may be used as relay stations to wirelessly transmit data acquired downhole to a surface location 56. In this manner, the data acquired downhole may be sent to the surface on a real-time or near-real-time basis. The control circuitry and power source for the transmitter 52 and receiver 54 may be contained in the cavities 18 formed in the various detachable sealed housings 10. The plurality of detachable sealed housings 10 may be spaced apart any desired distance that is consistent with reliable receipt and transmission of wireless data. That is, there may be multiple sections of pipe positioned between adjacent detachable sealed housings 10.

[Para 64] Figures 13A–13B depict yet another illustrative embodiment of the present invention. As shown therein, a drill string 60 is comprised of multiple

sections of wired pipe 62 and a downhole device 64 positioned between sections of wired pipe 62. Also depicted in Figures 13A–13B are a plurality of detachable sealed housings 10 of the present invention removably coupled to the wired pipe sections 62. Data wires 66 are schematically depicted in the wired pipe sections 62. As is known to those skilled in the art, data may be transmitted along the data wires 66 embedded within the wired pipe 62. To that end, the lengths of wired pipe 62 may be provided with an inductive coil 69 on both ends of each section of wired pipe 62 such that data may be transmitted from one section of pipe to another after the sections are joined together. According to this aspect of the present invention, one or more of the data wires 66 may be operatively coupled to one or more devices 29 in the one or more cavities 18 formed in each detachable sealed housing 10 to allow data to be transmitted to or received from the sensors 30 and/or electrical components 31 positioned within the removable sealed housing 10. The manner in which the data wires 66 may be operatively coupled to the sensors 30 and/or electrical components 31 are well known to those skilled in the art and may vary depending upon the particular application. Each of the detachable sealed housings 10 may further comprise a wireless transmitter 52 and a wireless receiver 54 as discussed above with reference to the embodiment shown in Figure 12.

[Para 65] In the embodiment depicted in Figure 13A, the detachable sealed housings 10 may be used to wirelessly transmit data from one section of wired pipe 62 to another spaced-apart section of wired pipe 62. In the depicted embodiment, the downhole device 64 is not wired, and may not be capable of being wired, e.g., a stabilizer. However, according to this aspect of the present invention, the transmitter and receiver in each of the detachable sealed housings 10 may be used to bypass the un-wired downhole device or assembly.

[Para 66] In general, in one embodiment, the present invention is directed to a removable sealed housing for equipment that may be employed in obtaining

downhole measurement data. In one illustrative embodiment, the apparatus disclosed herein comprises a component adapted to be positioned in a subterranean wellbore, the component having a recess formed therein, a detachable sealed housing removably coupled to the component, at least a portion of the detachable sealed housing being positioned in the recess, the detachable sealed housing having at least one cavity formed therein, and at least one device positioned in the cavity. In some applications, substantially all of the detachable sealed housing may be positioned within the recess formed in the component.

[Para 67] In another illustrative embodiment, the apparatus comprises a component adapted to be positioned in a subterranean wellbore, the component having a recess formed therein, a detachable sealed housing threadingly coupled to the component, at least a portion of the detachable sealed housing being positioned in the recess, the detachable sealed housing having at least one cavity formed therein, and at least one of a sensor and an electrical component positioned in the cavity.

[Para 68] In yet another illustrative embodiment, the apparatus comprises a component adapted to be positioned in a subterranean wellbore, the component having a surface, a detachable sealed housing removably coupled to the surface of the component, the detachable sealed housing having at least one cavity formed therein, and at least one device positioned in the cavity.

[Para 69] In one illustrative embodiment, the method comprises positioning a detachable sealed housing at least partially in a recess formed in a component adapted to be positioned in a subterranean wellbore, removably coupling the detachable sealed housing to the component wherein at least a portion of the detachable sealed housing is positioned in the recess formed in the component, the detachable sealed housing having at least one cavity formed therein and at least one device positioned within the cavity, positioning the

component and the detachable sealed housing in the subterranean wellbore, and acquiring data using the at least one device after the detachable sealed housing is positioned within the subterranean wellbore.

[Para 70] In another illustrative embodiment, the method comprises positioning a detachable sealed housing adjacent a surface of a component adapted to be positioned in a subterranean wellbore, removably coupling a detachable sealed housing to the surface of the component, the housing having at least one cavity formed therein and at least one device positioned within the cavity, positioning the component and the detachable sealed housing in the subterranean wellbore, and acquiring data using the at least one device after the detachable sealed housing is positioned within the subterranean wellbore.

[Para 71] The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. For example, the process steps set forth above may be performed in a different order. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.